Adjustable Voltage Power Supply

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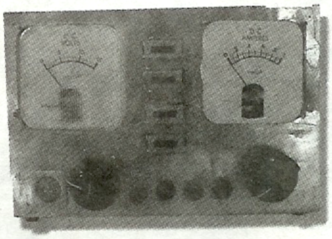
Electronics is a great hobby because you don't need a lot of money or fancy equipment to get involved. Once you're more involved in the hobby, there is a lot of equipment that will make prototyping and troubleshooting your circuits much easier. When you reach the point where you do need some fancier equipment, there's a good chance that you can build some of it yourself. As luck would have it, this article details an easy-to-build *Variable Power Supply* that works as well as ones costing hundreds of dollars—but this one costs less than $100 to build.

Features. The variable power supply features two independent outputs, both adjustable from 0 to 20 V_{DC}. It provides independent voltage and current monitoring for each output. Usually a benchtop power supply must be plugged into an AC outlet, but this one contains two lead-acid batteries that make it portable. This way you can bring it with you to surplus stores to test unmarked motors and other mysterious parts. In the event of a power outage you'll be able to continue working on your projects, even though you'll probably have more important things to worry about if the power is indeed out.



Circuitry. The complete schematic of the variable power supply is shown in Fig. 1. The circuitry is broken up into four parts: Power Control, Low-Voltage Indicator, Output and Controls, and the Battery Charger. There is no official PC board or layout you must follow to build this device, so feel free to do it however you like. You can build all of the circuitry at once or only the parts you want to include in your power supply. The author used a RadioShack proto-board for all the circuitry because it's easy to solder and new circuitry can easily be added for future modifications. Let's take a close look at each section of the circuit.

Construct a two-output power supply that produces 0 to 20 volts of DC power.

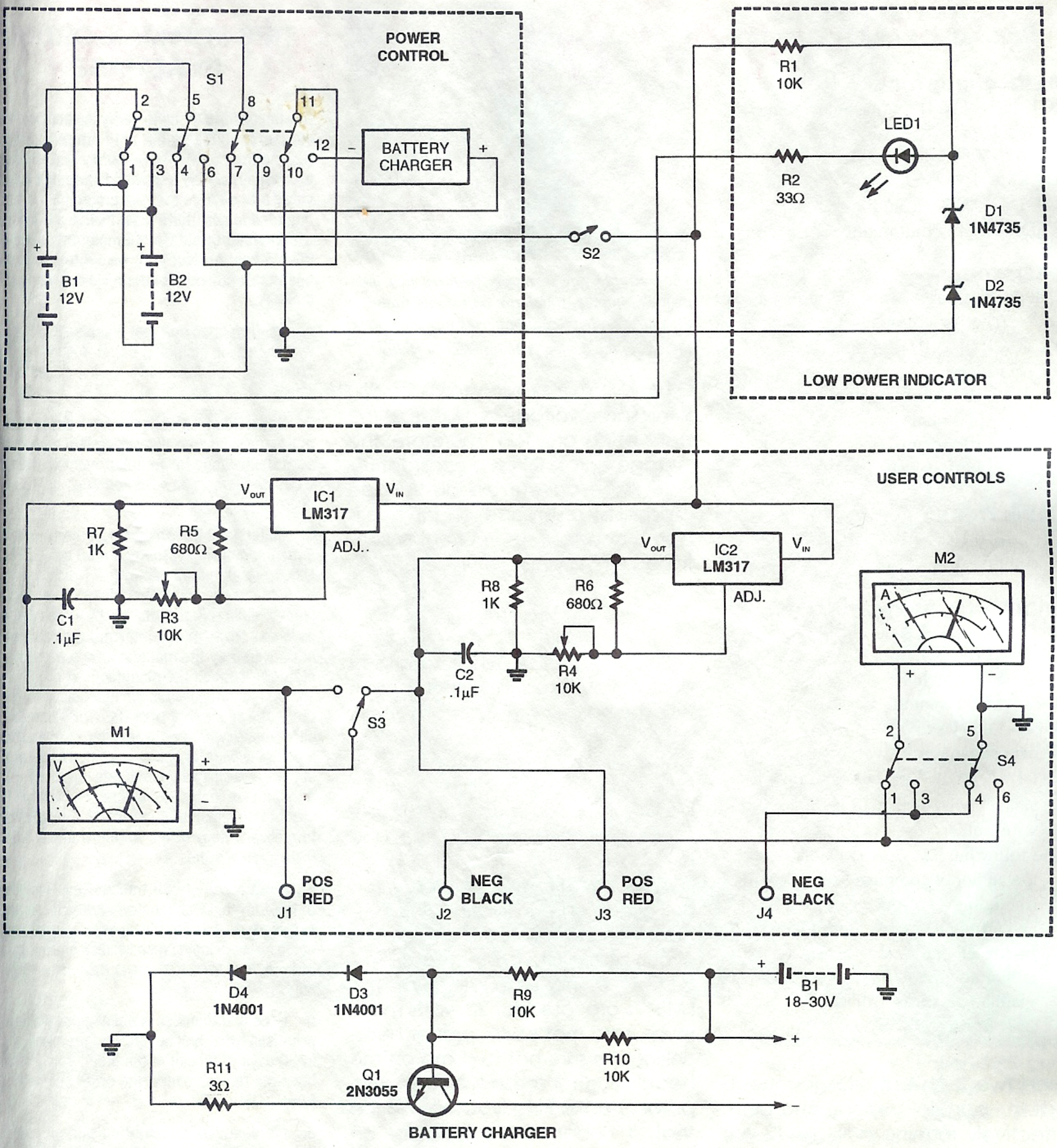
Power Control. The Power Control section controls the charging and discharging of the batteries (B1 and B2). The batteries are 2-Ah (*a*mpere-*h*our) lead-acid units, but you can use any Ah rating that you want—you'll simply get more or less run time. Switch S2 is an SPST unit that turns the power supply on and off during normal operation. Switch S1 is a four-pole *d*ouble-*t*hrow (4PDT) unit, whose wiring looks more complex than it really is. Moving the switch to the left position puts the unit in the "charge" mode by connecting the batteries in parallel to the battery charger. Moving the switch into the right position puts the batteries in series and connects them to the rest of the power-supply circuitry for the normal working mode.

Note that pins 1 through 6 of S1 control the series and parallel configuration of the batteries, and the rest of the switch contacts control the charge and discharge states. If it's more convenient, you can use two separate DPDT switches. Have one control the series/parallel connection of the batteries and the other control the charge/discharge mode.

WARNING: Be very careful when wiring this part of the circuit. Lead-acid batteries provide a high-current output. You can burn yourself very badly and cause all sorts of problems if you accidentally short out one of these batteries.

Low-Voltage Indicator. The low-voltage indicator tells when the batteries are low and require charging. When a lead-acid battery is fully charged, its voltage is around 13.8 volts; when fully discharged, it's around 10.7 volts. Zener diodes D1 and D2 (6.2-volt units) together create a 12.4-volt drop. When the battery voltage reaches 12.4V, the diodes short out the LED. As the series battery voltage decreases to about 20V (10V individually), the LED is no longer shorted. At this point, B1 no longer has a current path, but B2 does; and it flows through the LED to light it. If you want to increase or decrease the trip voltage, replace D1 and/or D2 with higher or lower voltage Zener diodes.

Output And Controls. Adjustable voltage regulators



ig. 1. Here is the schematic for the adjustable power supply. The circuitry is broken up into four parts: Power Control, Low-Voltage Indicator, Output nd Controls, and the Battery Charger.

C1 and IC2 (both LM317s) have a built-in 1.5-amp cur-ent limiter. The 10-K potentiometers (R3 and R4) let you adjust the output voltage from 0 to 20 volts. Capacitors C1 and C2 filter out high-frequency noise. he LM317s need a minimum load current of 3.5 mA to vork properly, so resistors R7 and R8 connected to the outputs provide the minimum required load. You can eplace R7 and R8 with lower valued resistors if you vant the outputs to go below 4 volts.

Banana jacks J1 and J3 are positive outputs, and J2 nd J4 are common-ground inputs. Switches S3 and S4 oggle between monitoring the outputs; S3 lets you switch between monitoring the voltage on J1 or J3, while S4 lets you monitor the current going into J2 or J4. S4 is wired so that whatever input isn't connected to the current meter is still connected to ground.

Battery Charger. The battery charger, obviously, charges the batteries when they get low. Basically Q1 forms a current source that is controlled by the resistance of R11. The maximum charging current that should flow through the batteries is one-tenth of the amp-hour capacity, so you have to select the value of R11 according to the batteries you use. The author

PARTS LIST FOR THE VARIABLE POWER SUPPLY

SEMICONDUCTORS

IC1, IC2—LM317 adjustable voltage regulator
Q1—2N3055 NPN power transistor
D1, D2—1N4735 6.2-volt Zener diode
D3, D4—1N4001 diode
LED1—Light-emitting diode, any color

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R9, R10—10,000-ohms
R2—33-ohms
R3, R4—10,000-ohm potentiometer
R5, R6—680-ohms
R7, R8—1000-ohms
R11—3-ohms, 3-watts (see text)

CAPACITORS

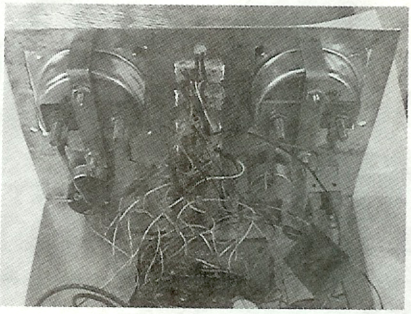
C1, C2—0.1-µF, 10%, 35-volts, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

SW1—4PDT switch
SW2—SPST switch
SW3—SPDT switch
SW4—DPDT switch
Female banana jacks, voltmeter, ammeter, 18- to 30-V_{DC} power supply, heat sinks, knobs, lead-acid batteries, wire, solder, case.
The following parts are available from the author: a complete kit of all parts (including a cut-out case) for $130 and a fully assembled unit for $160. Interested parties should contact the author at either *clt@kistech.com* or via mail at: Chris Troutner, PO Box 247, Boring, OR 97009.

used two 2-Ah batteries, connected in parallel when charging, effectively forming a single 12-volt 4-Ah battery. The maximum current that should flow through the two 2-Ah batteries while charging is 400 mA. Even though transistor Q1 is rated for high wattage, the author used a 3-ohm resistor (yielding a charge current of about 233 mA) to ensure that the transistor will never overheat.

If you want to use batteries other than the 2-Ah units, you have to calculate the proper value for R11. The current flowing through the batteries is effectively the same as the current going through R11, and the voltage dropped across diodes



The variable power supply features two independent outputs, which are adjustable from 0 to 20 V_{DC}. Two lead-acid batteries provide power; therefore, the device is completely portable.

D4 and D5 (approximately 1.2 volts) is the same voltage drop across the base of Q1 and R11. Therefore, the voltage across R11 is a constant 0.7 volt. Since current equals voltage divided by resistance, and the voltage is constant, the current is controlled by varying the value of R11

$$(I = VR_{11}/RR_{11})$$

So first decide what charging current you need, and then calculate the value of R11 accordingly.

Construction. Feel free to build this project however you like. Point-to-point wiring on perforated construction board will do just fine, and nothing is critical about the component layout. The author wired the circuit on a RadioShack protoboard and installed the completed circuit board in a case measuring 7 × 5 × 6 inches. Note that the LM317s are rated for 20 watts maximum, and that's with proper heatsinking. Be sure not to skimp on the heatsinking for these ICs. Even with proper heatsinking, you may notice that, if under heavy load for an extended period of time, the output voltage might drop a bit due to the LM317's built-in thermal protection. The IC will again work normally once it cools down. The only way around the problem it is to use additional heatsinking. ■